ROYAL MILITARY ACADEMY OF BELGIUM

PhD. Thesis Summary

By

HARIS BALTA

SPATIAL REGISTRATION OF 3D DATA FROM AERIAL AND GROUND-BASED UNMANNED ROBOTIC SYSTEMS

Robotic systems are more and more leaving the protected laboratory environment and entering our daily lives. These robotic entities can come in the form of aerial systems (drones), ground robots or unmanned maritime systems. Each of these robots gathers data about its environment for analysis and reasoning purposes. As more and more robotic systems are deployed, the amount of environmental data gathered by these systems also increases tremendously. This gives rise to a new problem: how to coherently combine the environmental information acquired by different robotic systems into one representation that is both accurate and easy to use by human end-users? In this thesis, we introduce novel methodologies to solve this data fusion problem, by proposing a novel framework for combining heterogeneous 3D data models acquired by different robotic systems, operated in unknown large unstructured outdoor environments into a common homogeneous model.

The first proposed novelty of the research work is a fast and robust ground-based 3D map reconstruction methodology for large-scale unstructured outdoor environments. It is based on an enhanced Iterative-Closest-Point algorithm and an iterative error minimization structure, as well as the fast and computational very efficient method for outlier analysis and removal in 3D point clouds.

The second proposed novelty of the research work is a registration methodology combining heterogeneous data-sets acquired from unmanned aerial and ground vehicles (UAV and UGV). This is accomplished by introducing a semi-automated 3D registration framework. The framework is capable to cope with an arbitrary scale difference between the point clouds, without any information about their initial position and orientation. Furthermore, it does not require to have a good initial overlap between the two heterogeneous UGV and UAV point clouds. Our framework strikes an elegant balance between the existing fully automated 3D registration systems (which often fail in the case of heterogeneous data-sets and harsh-outdoor environments) and fully manual registration approaches (which are labour-intensive).

A special and defining aspect of this PhD. work was that we did not only focus on investigating scientific and technical innovations, but that we also concentrated on bringing these innovations to the terrain in real operational environments in the security context. As an example, we deployed the technological tools developed in the framework of this research work to the field for demining and crisis relief operations in an actual crisis situation. This operational deployment was highly successful, based upon the feedback provided by the end-users.